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MINISTRY OF HOUSING AND LOCAL GOVERNMENT

Report of the Working Party on Grit and Dust Emissions

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The Working Party on Grit and Dust Emissions was set up in September 1964 to advise the Minister of Housing and Local Government on grit and dust emissions from industrial and other similar furnaces. Its terms of reference were:

> " To consider ways and means of measuring grit and dust emissions and to advise on the levels of emission admissible in relation to furnaces burning fuel equivalent to 100 to 50,000 pounds per hour of coal."

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Chapter 1

SOLID FUEL-FIRED BOILERS

Introduction and General Observations

1. We have interpreted the word "furnaces" in our terms of reference as meaning (a) solid fuel-fired boilers, air heaters and solid fuel-fired furnaces, in which the medium to be heated is not in direct contact with the flue gases, (b) oil-fired boilers, air heaters and oil-fired furnaces in which the medium to be heated is not in direct contact with the flue gases, and (c) furnaces in which the flue gases are in direct contact with the medium.

2. For the purpose of this enquiry, we have accepted the definition of grit as being material greater in size than a 200-mesh British Standard (B.S.) sieve (75 microns) and dust as material less than 200-mesh B.S. sieve in size.

3. Because of the known difficulties in sampling grit and dust, we advise that our recommendations should be reviewed after they have been in operation for three years. The Ministry of Housing and Local Government will have to consider carefully how the necessary facilities and authority for sampling and measurement should be provided.

4. We have not concerned ourselves with what emissions of grit and dust constitute a statutory nuisance within the meaning of the Public Health Act 1936 in the almost infinite variety of circumstances encountered by local authorities. Our guiding principle has been to have regard to what is reasonable and practicable from an engineering and operational point of view and, in a general sense, to be sensible about the cost of meeting the standards. This is not in conflict with the spirit of the Clean Air Act 1956.

5. As a Working Party, we have not undertaken any practical investigations, as to do so would have delayed our report for a very long time. Our conclusions are based on what was already known to us. We have been fortunate in having had made available to us the considerable quantitative data and experience of the National Industrial Fuel Efficiency Service (N.I.F.E.S.) and we here record our thanks for this.

6. It is doubtful if local authorities and industrialists generally have significant experience of measuring grit and dust emissions in a systematic and purposeful way and of applying the results of such measurements to the control of atmospheric pollution. The magnitude of the task should not be underestimated. To do the job properly is time-consuming and costly and the measurement of grit and dust emissions should not be undertaken lightly.

7. We are satisfied that the standards we have proposed can be met if the plant is reasonably modern, efficiently operated and well-maintained. These are prerequisites and the first approach by industry and local authorities to a problem of potentially excessive emission is to satisfy themselves that these conditions pertain. For example, it is well established that for many sizes and types of boilers a simple and comparatively cheap grit arrestor will often suffice. But these arrestors require regular and competent maintenance, otherwise they do not function properly. Moreover, no grit arrestor works satis-

factorily if it is not emptied regularly. The grit and dust from the collector should be removed from the site, without delay and disposed of without creating a nuisance. There is not much point in carrying out elaborate measurements of grit emission if the plant is inefficiently operated and in a bad state of repair, or if the equipment for arresting grit and dust provided by the owners of the plant is not used properly. These shortcomings should first be rectified.

8. The standards that we propose assume that for new plant the chimney heights and efflux velocities are as recommended in the "Memorandum on Chimney Heights" issued to local authorities by the Ministry of Housing and Local Government and the Scottish Development Department in 1963. If chimney heights are less than those calculated from the Memorandum, then the possibility of causing nuisances in the surrounding areas is increased.

9. We realise that there may be existing plant where to install grit arrestors or more modern firing equipment would involve the owners in costly mechanical and civil engineering works and, thereby, impose a recognisable hardship. In these circumstances, additional to the test of what is reasonable and practical from a cost point of view, regard should be paid to endeavouring to operate such congested plant as efficiently as possible. The more efficient the plant, the less is the amount of fuel used and correspondingly the less the amount of total emissions. There is little doubt in our minds that there is much that can still be done in this way to reduce the nuisance from the emissions of grit and dust. In some circumstances, a change to another grade of fuel may be worthwhile.

10. Where the installation of new plant is concerned, there seems to us to be no good reason why our proposals should not be applied by all concerned. Here we would add a rider that it should be obligatory so to arrange the layout of the plant that the sampling of the emission can be carried out properly and with the least trouble and that suitable sampling points should be provided.

The Method of Sampling

11. The members of the Working Party who have had practical experience of measuring grit and dust in a variety of circumstances were unanimous in saying that the cyclone probe method developed by the British Coal Utilisation Research Association (B.C.U.R.A.) was basically sound and had proved to be reliable in use. And this is the method that we recommend.* The data on the emissions of grit and dust from boilers that were available to us and which helped us to fix the proposed standards were all obtained by this method.

12. We make one qualification; we do not think that it is necessary to filter the gas sample after the cyclone. The use of the filter complicates the pro-

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*A detailed description of this method is given in "Measurement of Solids in Flue Gases" by P. G. W. Hawksley, S. Badzioch and J. H. Blackett, published by the British Coal Utilisation Research Association in 1961, and particularly Part One, pages 13 to 26. The apparatus can be obtained from Airflow Developments Limited, Lancaster Road, High Wycombe, Buckinghamshire. The apparatus is described in B.S. 3405, but the procedure of sampling that we recommend differs from that described in this Standard.

cedure and the amount of particulate matter collected on the filter rarely exceeds 10% of the total solids and is usually within the range 2-5%. The non-use of the filter is not an absolute rule, because where there is reason to believe that the solids in the flue gases are friable such as, for example, when sampling the emission from an incinerator, and, therefore, likely to be broken up into smaller particles in the cyclone, then the filter should be used.

13. We have preferred to express our standards of admissible emission in pounds of grit and dust emitted per hour during periods of normal operation of the boiler. We recommend that the period of sampling shall be selected to embrace the conditions described as "normal". There is no absolute definition of "normal" and this can only be decided by observing the cycle of operations of the plant in question for some time before measuring the emission. The "normal" should, of course, include the periods when customary peak loads on the boiler plant obtain.

14. Sampling should preferably be carried out in the chimney or as near to the chimney as possible. If the plant includes a grit arrestor, then sampling should be after the arrestor. If the arrestor is so placed that this cannot be done, then sampling will have to be done at a point before the arrestor, and during the period of test the weight of grit and dust collected in the arrestor should be obtained starting, of course, with an empty arrestor. Appendix I gives guidance on the position of the sampling point.

15. It is not likely that the dust burden will be uniform throughout the cross section of the flue or chimney and, consequently, we recommend that samples should be taken at a minimum of four points uniformly distributed across the section.

16. The capacity of the cyclone in the sampling probe is such that sampling, which should be isokinetic, cannot be continued in many plants for more than about fifteen minutes, after which the cyclone becomes overloaded with grit and dust. Taking the samples at the minimum of the four points recommended represents one hour's sampling and, as shown in Appendix II, this gives one result.

17. It would be wrong to take a view on the amount of emission from a plant on one result and we recommend that on the same visit at least three results should be obtained. Our experience shows that to do this would occupy the sampling team about eight hours of their time. An example of the method of calculating the results is given in Appendix II.

18. If the measured emission (i.e. the mean of the three results) is well within the recommended standard for the plant in question, and if the condition and method of operation of the plant are convincingly in accord with this, then perhaps a repeat survey may not be necessary, but generally no decision on the level of emission should be taken without making a repeat survey on another occasion within a week or two.

19. We have not expressed the standards in terms of grains per cubic foot (cu. ft.) because the solids concentration depends on the amount of dilution by excess air and by any air that may have infiltrated into the flue. The sampling procedures would have to be further elaborated by a measurement of the percentage of carbon dioxide (CO_2) to estimate this dilution and to correct the observed concentration to reference conditions (e.g. 12% CO_2 corresponding to 50% excess air).

The Levels of Admissible Emission

20. We have made certain assumptions in deciding the emissions not to be exceeded:

(a) The standard shall be stated in pounds per hour (lb/h) of grit and dust emitted in a period of normal operation, including peak loads.

(b) The amount of grit and dust expressed as a percentage of the fuel burned shall be greater for small plants than big plants and shall range between 0·5% of the fuel burned at the upper limit of firing rate of 50,000 lb fuel per hour and 1·0% at and below a firing rate of 670 lb fuel per hour.

(c) Our standards are stated graphically in terms of the Maximum Continuous Rating (M.C.R.) expressed in lb steam per hour from and at 212°F. For all boilers with M.C.R.'s of 25,000 lb steam per hour and less, we have assumed a steam/coal ratio of 7·5. For boilers within the M.C.R. range 25,000 lb/h and 475,000 lb/h (from and at 212°F), we have assumed that the steam/coal ratio increases linearly with rating from 7·5 to 9·5. All boilers within this higher range have to be fitted with efficient grit and dust arrestors. Where more than one boiler is connected to a chimney, the admissible level of emission from the chimney will be the sum of what is admissible for each of the steaming boilers connected to the chimney.

(d) We recognise that the emission of grit and dust varies considerably in time and that the method of sampling will at best give a result only within certain confidence limits. The more samples that are taken the narrower the confidence limits of the mean result. For boilers with reasonably steady efficiencies the 95% confidence limits will be about ±13% using the recommended apparatus and method.* Ideally the admissible standards should be expressed in statistical terms, but a long and exhaustive study would be necesasry before this could be done, It is necessary to emphasise to local authorities that the standards are not of a simple "pass/fail" nature and should not be applied in this way. They should be applied in a commonsense way having regard to all the circumstances.

(e) We have not dealt separately with the emissions during soot blowing and have considered that periods of soot blowing should be excluded from any interpretation of the standards. If it is thought that soot blowing is causing a local nuisance, then this operation should be studied separately and by people skilled in dealing with this aspect of the problem.

(f) We have dealt with the relative emissions of grit and of dust by a simple generalisation that the amount of grit (the particles greater than 200-mesh B.S. sieve) should not exceed 33% of the total solids emitted from plants burning up to one ton of coal per hour and for plants burning more than one ton of coal per hour the grit should not exceed 20% of the total emissions.

21. The standards are presented graphically in Figures 1A and 1B.

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*Table 12, page 132 of "Measurement of Solids in Flue Gases" by P. G. W. Hawksley, S. Badzioch and J. H. Blackett.

Chapter 2

OIL-FIRED BOILERS

Introduction and General Observations

1. Here again our main concern has been to determine the admissible standards on the basis of what is reasonable and practicable from an engineering and operational point of view and to be sensible about the cost of meeting the standards. We have assumed that grit arrestors would not be fitted to oil-fired boilers.

2. We have not carried out any experimental work, but have been guided largely by what was already known to us. As with the solid fuel-fired boilers we have been helped by the experience of National Industrial Fuel Efficiency Service (N.I.F.E.S.) which was fully made available to us. Additionally we have been greatly helped by the evidence of Mr. E. Briggs of Shell Mex and British Petroleum (B.P.) Limited who made available to us the results of the considerable detailed investigations of the emissions of grit and dust from Shell boilers carried out jointly by the Shell boilermakers, the burner manufacturers and the oil companies. The information arising from these extensive studies was put freely at our disposal. In determining the standards for the larger boilers we have had regard to published data on solids emissions.

3. As we said in chapter I the standards that we propose assume that for new plant the chimney heights and efflux velocities are as recommended in the "Memorandum on Chimney Heights" issued to local authorities by the Ministry of Housing and Local Government and the Scottish Development Department in 1963. If chimney heights are less than those calculated from the Memorandum, then the possibility of causing nuisances in the surrounding areas is increased.

4. The intermittent and somewhat sporadic emission of acid soot is a separate issue from the emission of grit and dust as understood in this report and the standards that we propose. The acid soot arises from the condensation in chimneys and flues. For the very noxious emission of acid soot to be eliminated, it is essential that the temperature of the surfaces in the flues and chimneys should be kept above the acid dewpoint. To achieve this with any certainty with modern oil-firing equipment, it is necessary that the exit flues and chimneys should be properly insulated and that the plant should be operated in such a way that condensation will be prevented. It is doubtful if a satisfactory code of practice for the construction of exit flues and chimneys has yet been established and we recommend that the Ministry of Housing and Local Government should have discussions with the boilermakers and those who construct chimneys to this end. Eventually it may be desirable to have a British Standard.

5. As in the chapter on solid fuel-fired boilers we repeat that for new plant it should be obligatory so to arrange the layout of plant that the sampling of the emission can be carried out properly and with the least trouble and that suitable sampling points should be provided.

Method of Sampling

6. Ideally the same equipment and method of sampling should be used for oil-fired boilers as for the solid fuel-fired boilers. In the method recommended for solid fuel-fired boilers we said that it was unnecessary to incorporate a filter in the B.C.U.R.A. equipment. Because of the nature and size of the solids emitted from oil-fired boilers it is essential that a filter be incorporated after the cyclone. The filtering medium should be silica wool.

7. It is known that a number of organisations have successfully used the B.C.U.R.A. method on oil-fired plants and accordingly we recommend that this method should be used by local authorities. We have learned that the method developed by the Fuels Research Branch of the B.P. Research Centre, Sunbury-on-Thames, and described by L. K. Rendle in the Journal of the Institute of Fuel, January 1964, and which is used by the oil companies gives almost identical results to the B.C.U.R.A. method and for all practical purposes can be considered as an alternative. This method can therefore be used for determining the emissions and for some flues or chimneys this may be a more convenient method.

8. As in the case of solid fuel-fired boilers we have preferred to express our standards of admissible emission in pounds of grit and dust emitted per hour during periods of normal operation of the boiler. The following recommendations first set out in paras. 14, 15 and 16, of Chapter I are equally applicable to oil-fired boilers. (a) The period of sampling shall be selected to embrace the conditions described as "normal". There is no absolute definition of "normal" and this can only be decided by observing the cycle of operations of the plant in question for some time before measuring the emission. The "normal" should, of course, include the periods when customary peak loads on the boiler plant obtain. (b) Sampling should preferably be carried out in the chimney or as near to the chimney as possible. (See Appendix I). (c) It is not likely that the dust burden will be uniform throughout the cross section of the flue or chimney and, consequently, samples should be taken at a minimum of four points uniformly distributed across the section.

9. The dust burden in the exit gases from an oil-fired plant is lower than from a solid fuel-fired plant and, consequently, sampling at any point in the chimney or flue can be carried out for a longer period before the cyclone and filter become overloaded. With the solid fuel-fired boilers we said that it is unlikely that sampling at any one point could be continued for more than a quarter-of-an-hour. With oil-fired boilers the sampling can be continued for a longer period, say, half-an-hour. This being so, it may only be possible in an 8-hour shift to obtain two results. The method of calculating the results is the same as that described in our first chapter.

10. If the measured emission (i.e. the mean of the two results) is well within the recommended standard for the plant in question, and if the condition and method of operation of the plant are convincingly in accord with this, then perhaps a repeat survey may not be necessary, but generally no decision on the level of emission should be taken without making a repeat survey on another occasion within a week or two.

The Levels of Admissible Emission

11. We have made certain assumptions in deciding the emissions not to be exceeded:

(a) The standard shall be stated in lb/h of grit and dust emitted in a period of normal operation, including peak loads.

(b) The emission from boilers with M.C.R.'s up to 40,000 lb/h from and at 212°F shall be 0·4% of the fuel burned at M.C.R. on the basis of a steam/oil ratio of 14·3 assuming oil with a calorific value of 18,500 Btu/lb and using 971 Btu for the heat required to generate 1 lb of steam from and at 212°F.

(c) The emission from boilers with M.C.R.'s in the range 40,000-475,000 lb/h from and at 212°F shall decrease steadily in the same manner proposed for solid fuel-fired boilers from 0·4% at the lower end to 0·2% at the top of the range with the steam/oil ratio increasing linearly from 14·3 at 40,000 lb/h to 16·75 at 475,000 lb/h.

(d) We have not dealt separately with the emissions during soot blowing and have considered that periods of soot blowing should be excluded from any interpretation of the standards. If it is thought that soot blowing is causing a local nuisance, then this operation should be studied separately and by people skilled in dealing with this aspect of the problem.

(e) We are not able to set any limits for the emission of grit (particles of size greater than 200-mesh B.S. sieve) as a percentage of the total emission.

(f) Where more than one boiler is connected to a chimney, the admissible level of emission from the chimney will be the sum of what is admissible for each of the steaming boilers connected to the chimney.

12. The standards are presented graphically in Figures 2A and 2B. We recommend that these standards should be reviewed after they have been in operation for three years, because we believe that if the best engineering and operational practices are adopted lower emissions than those proposed may be achievable without undue hardship, particularly in the range in Figure 2B.

Chapter 3

FURNACES

Introduction

1. For good reasons we have found the task of reporting on the emissions of grit and dust from furnaces to be the most difficult part of our study and, in fact, we are not able to put forward a comprehensive set of standards of emissions not to be exceeded.

2. There are very few reliable data of emissions from furnaces and until representative surveys have been carried out there will not be enough data to be able to judge what standards are reasonable and practicable. The problem is greatly complicated because of the large variety of furnaces, both in size and type. Also there is the added complication that many different kinds of materials are heat treated. Some do not change their properties during the heating process or materially add to the emissions, whereas others undergo physical and chemical changes in the furnaces and, in so doing, emit grit, dust and fume into the waste gases and some of this escapes into the atmosphere. Furthermore, so far as we can judge, the technology of dealing with emission by gas washing, using cyclones, or by means of precipitators has not yet reached the measure of standardisation and precision which obtains with steam-raising plant.

3. These are somewhat general remarks and are not based on a systematic study of the present state of practice and of the art of emission control. It would have been a long and arduous task for the Working Party to have made such a study, but the need for a good study is imperative and we have recommended accordingly.

Sampling

4. The method of sampling that we have proposed for boilers is equally applicable to furnaces and we recommend this method. Where fume is a major component of the emission, or where the gas is at a very high temperature, some special attention may have to be given to modifying the sampling apparatus.

The Classification of Furnaces

5. To make our task manageable, we have attempted to classify furnaces on the basis of the jobs that they have to do and the kinds of material that are treated. We have not attempted any sub-divisions of the six broad classes in terms of size of furnace or throughput. For some of the classes these may also be relevant factors. There is an added complication in that many types of furnaces are dealt with under the Alkali &c Works Regulation Act 1906 and some of the emission problems from such furnaces are dealt with by the Alkali Inspectors of the Ministry of Housing and Local Government. No doubt when the Ministry come to consider our recommendations they will eliminate those furnaces and industries already catered for by another procedure.

6. Our suggested classification of furnaces is given in Appendix III. When we were considering the standards of emissions that might be applied to these various classes of furnaces, we concluded that we could only recommend standards for the two classes, Indirect and Heating Furnaces. The

standards that we propose for these are somewhat more tentative than our boiler standards. But we think that they are reasonable enough to be given a three-year trial.

Indirect and Heating Furnaces

7. Our recommended standards for boilers are related to the M.C.R. of the boilers from and at 212°F. We found no common basis for the rating of furnaces to which we could line up our standards. Accordingly, for these two classes of furnaces we have had to relate our standards to the heat input in Btu/h. In fact, what we have done is to make a straight conversion of the M.C.R. from and at 212°F scales of our boiler standards to the equivalent in Btu/h. Our recommended standards are given in the appended graphs, Figures 3A, 3B, 4A and 4B.

8. This means that furnace users and those who test them for emissions will have to provide reliable data on fuel consumption and calorific value, and to this extent the implementation is that much more difficult. We have assumed that there will be no emission problems with these types of gas-fired or electrically-heated furnaces.

Drying, Sintering and Melting Furnaces and Incinerators

9. We are not able to recommend standards of emissions for these furnaces. We do not think that sufficient is known about the various problems and, accordingly, we recommend that the Ministry should initiate a systematic study to obtain emission data from a representative sample of these classes of furnaces and, at the same time, get some reliable information on the current technology of emission prevention. We feel that if such an investigation was carried out purposefully and well organised perhaps enough information could be obtained in a period of 12 to 18 months from the start of the investigation.

10. We have given some thought to the organisation best fitted to make such an investigation and we are unanimous in recommending that N.I.F.E.S. should be chosen. We have not gone into the cost of doing such an investigation in detail but, at a rough guess, we think that for about £20-25,000 enough data on which to base standards could be obtained. We recommend that this investigation be started without delay and that it should not wait for the setting up of the Working Parties referred to in the next paragraph.

11. We do not think that the present Grit and Dust Working Party is properly constituted to undertake the task of formulating standards for these four classes of furnaces and we recommend that new Working Parties should be set up immediately for each of the four classes with some common membership to ensure a common approach. Perhaps the Ministry's representation would suffice for this purpose and if N.I.F.E.S. are engaged to carry out the investigation we have recommended they, too, could provide common membership. There should be some independent scientists, engineers or technologists, but above all the industries concerned should also be well represented. Active collaboration with industry on this matter is essential and we believe that this can be obtained.

Chapter 4

GENERAL OBSERVATIONS

Introduction

1. During the course of our discussions certain general matters were raised which we felt could best be dealt with in a separate chapter. We have tried to keep strictly to our terms of reference which were simple and clear; we have not thought it necessary to relate these to the Clean Air Act or to attempt a dissertation on the Act insofar as it concerns emission standards and the powers of the Minister and the duties and responsibilities of local authorities. It is certain that both industry and local authorities will have to do much more than they are now doing if these standards are to be achieved and to be able to demonstrate by inspection and measurement that they are.

Methods of Sampling

2. We selected one method only for solid fuel-fired boilers and recommended the same method for oil-fired boilers, but also said that the Sunbury method was an alternative which, in some conditions, might be the more convenient method for oil-fired boilers.

3. The British Standard (B.S.3405) describes five methods and in some respects a procedure of sampling which we have not followed. We recommend that the British Standards Institution should give further consideration to this matter.

4. We have recommended that sampling should be carried out at a minimum of four points. It should be pointed out that for some ducts and chimneys sampling may have to be carried out at many more points if a reasonably accurate result is to be obtained.

Facilities for Sampling

5. We have no evidence of a local authority carrying out sampling or that industry generally samples in a systematic way. We are strongly of the view that the Ministry should immediately consult with local authorities to work out a scheme whereby our recommendations can be given a proper trial within the next three years. It will also be necessary to obtain the full co-operation of industry. Most industries have their own Research Associations and these Associations should be asked to co-operate. Whatever is ultimately decided as the appropriate way of getting quantitative data on emissions, a more extensive use could be made of the services of N.I.F.E.S., who have the necessary skill and experience.

Training of Samplers

6. Sampling the emissions of grit and dust is a skilled and time-consuming job. If action is taken on this report, it will be necessary to train a fairly large number of people to do the job properly. We recommend that arrangements should be made for the training of the samplers at a few centres in the country (say, one in the North, London, and the West) until reliable knowledge of this subject is widely dispersed. We feel that N.I.F.E.S. is well equipped to do this training and the centres could be at some of their Area Offices with facilities for demonstration at nearby works.

Rapid Methods of Sampling and Monitoring

7. It was suggested to us that it would be helpful if there was a rapid simple method for carrying out preliminary surveys. We are unable to recommend a method and, therefore, we advise that the Ministry should take steps to initiate a research programme to this end, or at least to get an appreciation of whether it is likely to be possible to develop a suitable rapid method of assessing the emissions. We considered whether it would be practical to have some method of monitoring in the chimney the emission of grit and dust. We were aware of the method that has been developed by the Central Electricity Generating Board, but we do not think that this method is generally applicable to the range of equipment that we are concerned with. However, should someone devise a comparatively simple instrument that is reasonably reliable then further thought can be given to this. But we think that this is a long way off.

The Standards

8. In formulating the standards we had regard to simplicity and also the fact that we did not think it practical at this stage to formulate standards that would involve the people concerned in elaborate measurement of boiler performance. Accordingly, we chose the M.C.R. from and at 212°F as one of the parameters. We are well aware that some boiler plant will operate below the M.C.R. and to that extent may be favoured. The alternative would have been to have stated the standards in terms of heat input, and some members of the Working Party favoured this. But, as this would have involved obtaining accurate measurements of fuel consumption and the calorific value, the majority view was for the M.C.R., and we have reported accordingly. We were forced in the standards for furnaces to use heat input as the basic parameter and to that extent the procedures are more burdensome.

9. In our informal discussions with the technical representatives of the Water-Tube Boilermakers' Association, it was suggested to us that our standards for solid fuel-fired boilers should have incorporated some factor which would relate the standards to the ash content of the fuel. There are other factors which influence grit and dust emission such as the moisture and fines content of the coal. We have considered it wrong to relate the standards to the quality and nature of the fuel. This must be taken care of by the methods of operation of the plant and the choice of the dust arrestment equipment and by the common sense dealings between the suppliers and users of the fuel.

The Extent to which Plants are presently conforming to the Standard

10. No one is able to say with any degree of certainty what proportion of existing plants conform to the standards and how difficult and costly it will be to bring within the standard those that do not conform. The trial period of three years that we have recommended should go some way to answering these questions. We have no hesitation in saying that for new plant installed from now on it should be a condition of approval that the plant is capable of meeting the standards, and industry should be advised that it should be part of the specification that the plant when reasonably operated will conform. Industry would be well advised to give themselves a factor of safety on these standards.

The Clean Air Act 1956

11. In making our recommendations, we have kept strictly to our terms of reference and have resisted the temptation to relate them to the Clean Air Act. However, we have noted that in the part of the Act dealing with Grit and Dust from Furnaces (Sections 5 to 10) there are frequent references to solid fuel (and waste) but no specific references to the use of oil or gas. Some people may read into this that the use of oil and gas is exempted from the grit and dust provisions of the Act. We cannot say how sensible such a viewpoint would be and we have ignored it on the basis that our terms of reference speak of "fuel equivalent to . . . . ." and so we have made recommendations in respect of oil as well as solid fuel.

Signed on behalf of the Working Party

D. HICKS
(*Chairman*)

Appendix I

CHOICE OF SAMPLING POSITION

The sampling position should be chosen to satisfy the following conditions:

(i) It should preferably be downstream of any settling chamber, grit arrestor, or gas-cleaning plant and of any place in the flue system — such as a long horizontal duct — where grit and dust may be deposited. It may, however, be located at an upstream position if the amount of grit and dust removed in the gas cleaner or deposited from the flue gases is measured simultaneously over the period of sampling.

(ii) It should not be closer than one flue diameter to any upstream disturbance such as a bend.

(iii) It should be at a position where the flue gases are flowing substantially parallel to the axis of the flue and not pursuing a helical path, such as may occur downstream of a cyclone-type gas cleaner.

(iv) It should be chosen so that the flue gas velocity at any sampling point at the position is such that the pitot pressure difference is not less than 0·02 inch water gauge (corresponding to about 12 feet per second) and there is no "dead" space, or region of reversed flow (0·02 inch water gauge is the lowest pressure difference that can conveniently be measured under field conditions).

Until experience has been gained, it may be difficult to choose a sampling position to meet these requirements, but the following observations may assist.

A sampling position can be accepted if the flue gases do not deviate by more than 30° from the axis. The direction of flow of flue gases will deviate excessively at a position immediately after a right-angle bend, but unless the velocity is high and the flue small it will probably be satisfactory to sample at a distance as close as one flue diameter from the bend (for rectangular flues, at a distance equal to the width of the flue in the plane of the bend). Sampling may be closer still if the bend is less sharp. It is permissible to sample in divergent or convergent flues unless the included angle of the walls is more than 60°. A position at one flue diameter or so from the exit of the induced draught fan will be suitable unless the flue diverges too rapidly (especially the inner wall nearest the fan axis) when the flow may be so concentrated at the outer walls as to produce an eddy flowing in the reverse direction near the inner wall. The junction of two flues, whether gases are flowing through both or whether one is blanked off, should be regarded as a right-angle bend. Sampling can be carried out immediately after louvre- or butterfly-dampers provided they are fully open, but if they are partially closed (and whenever the flue contains other obstacles) it may be necessary to sample more than three or four obstacle diameters downstream. A downstream bend will have some influence on the direction of flow and it is inadvisable to sample closer than one-half of a flue diameter in front of a bend.

An important case where solids and gases do not flow parallel to the axis of the flue is in the exit ducting from a cyclone-type gas cleaner. The spin induced in the cyclone to remove the solids continues in the exit ducting and the helical flow dies away only very slowly unless radial blades or honeycombs are fitted, but these "correcting vanes" may not always be adequately effective. Some other sampling position must then be chosen.

Appendix II

EXAMPLE OF CALCULATION OF EMISSION

Measurements are made at four points within a duct of internal dimensions 4 ft 4 in by 3 ft. The plant has a rated capacity of 50,000 lb steam/h. The sampling points are located at the centres of the four equal rectangles into which the duct is imagined to be subdivided. Sampling is carried out isokinetically and each point is sampled for fifteen minutes using a sampling nozzle of area 1/150 sq. ft. (that is, 1·106 inch diameter). The samples are taken in random order. The weights of solids collected are 1·15, 1·32, 3·78 and 2·92 gramme (g) for the fifteen minute sampling duration. The rates of collection of solids are, therefore, 4·60, 5·28, 15·12 and 11·68 g/h. The average rate is 9·17 g/h or 9·17/453·6 = 0·0202 lb/h. Since the duct is 4 ft 4 in by 3 ft internal dimensions, its cross sectional area is 13 sq ft. This area is 13 ÷ 1/150 = 1950 times the area of the sampling nozzle. The emission is, therefore, 0·0202 × 1950 = 39·4 lb/h.

Similar measurements are made in two other one-hour sampling periods giving emissions of 34·6 and 45·8 lb/h.

The average emission for the total 3-hour sampling period is 40 lb/h, which exceeds the maximum emission, given in Fig. 1A, of 37 lb/h for a plant rated at 50,000 lb steam/h. A repeat test is indicated before a decision can be taken.

Appendix III A SUGGESTED CLASSIFICATION OF FURNACES

Classification Heading	*Brief Explanation*	*Some Examples*	*Notes on Emissions*
Indirect Furnaces	The material is separated from the hot gases.	Muffle furnaces, pack type annealing furnaces, vertical retorts, air heaters.	The emission in the products of combustion should be regulated as for boilers, but using Btu input instead of steam output. In cases where emission occurs from material (zinc retorts, etc.) this is usually covered by the Alkali &c, Works Regulation Act, 1906.
Heating Furnaces	Where the material does not change its state and little or no chemical reactions occur which liberate dust or fumes.	Billet and sheet re-heating furnaces, brick kilns, not involving glazing, tunnel kilns.	These again should not give any extra emission problems, and should be regulated as for boilers, using Btu input basis.
Drying Furnaces	Where material is often agitated to improve rate of drying.	Sand dryers, spray driers, roadstone dryers.	In these, fuel consumption may be quite low compared to the weight of material dried, and as fine dust carried over might only be removed in a cyclone or multicyclone unit, it might be necessary to allow an addition to the emission that has been calculated from the Btu input of fuel of, say, a very small percentage of material handled, this percentage decreasing with increasing size of furnace.
Sintering Furnaces	Where material is heated to high temperatures and may be agitated.	Cement kilns, ore roasting, salt-cake furnaces.	A considerable emission occurs from material, and again allowance may have to be made for this, as otherwise a 100% collection efficiency of material dust would be necessary, but this is impractical.
Incinerators	Where material is heated and "burns".	Waste product incinerators, rubber removal from cable scrap, oil removal from metal swarf.	Sometimes no "fuel" is used, since heat from burning material may keep the furnace up to temperature. Emission may have to be based on some percentage of material burned, or on grains per cubic foot at a standard CO_2 figure.
Melting Furnaces	Where material is melted for further processing.	Cupolas, glass tanks, open hearths, electric arc, pot melting furnaces, bale-out furnaces, *etc.*	Much of the emission may be due to metal and oxide particles. Again emission may have to be based on some percentage of materials, or on grains per cubic foot.

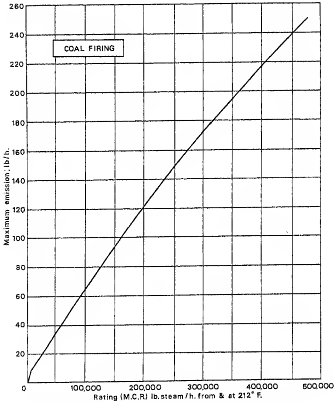

Fig. 1A Proposed maximum emission from coal-fired boilers

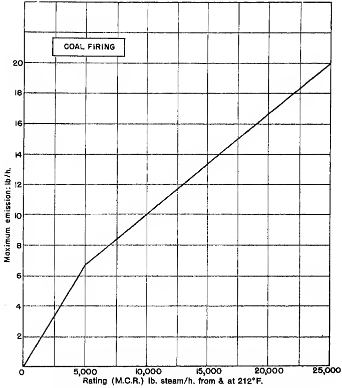

Fig. 1B Proposed maximum emission from coal-fired boilers

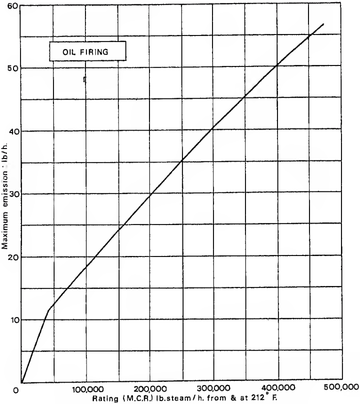

Fig. 2A Proposed maximum emission from oil-fired boilers

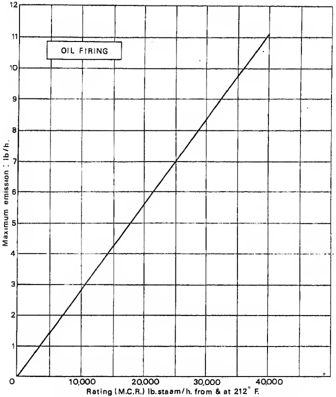

Fig. 2B Proposed maximum emission from oil-fired boilers

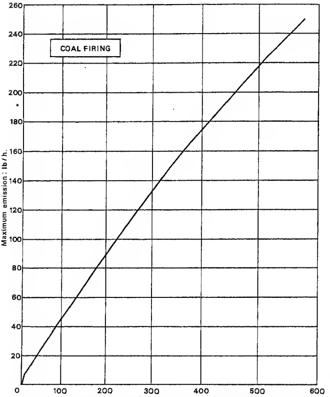

Fig. 3A Proposed maximum emission for coal-fired furnaces where the stock does not contribute to the emission.

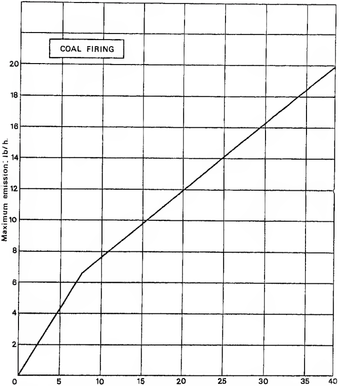

Fig. 3B Proposed maximum emission for coal-fired furnaces where the stock does not contribute to the emission.

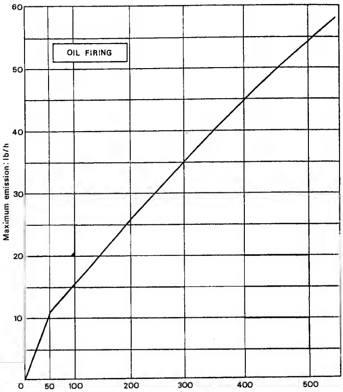

Fig. 4A Proposed maximum emission for oil-fired furnaces where the stock does not contribute to the emission.

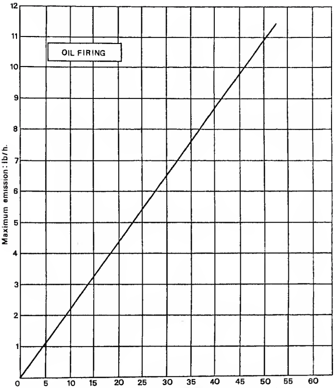

Fig. 4B Proposed maximum emission for oil-fired furnaces where the stock does not contribute to the emission.

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